The Integrator

Volume 9, No. 3 | Published by the Mission Services Program Office | November 2000

A Message from the Associate Director / Program Manager for Mission Services

As the calendar year draws to a close I've begun to reflect on our accomplishments and consider what lies ahead in the next year. The number of missions we supported increased substantially relative to past years, and is likely to increase even more next year. The increase has impacted neither our ability to work effectively with our customers nor our ability to provide flawless launch and checkout support while maintaining outstanding network support.

In the past few years our operating environment has been affected by several significant changes. A government-wide move toward outsourcing services, and the shift of full cost responsibility to Projects are two examples. We continue to work closely with Center-level management and our Flight Programs and Projects Directorate managers to effectively reorganize the Mission Services Program. The proposed organizational structure is consistent with external changes and, I believe, will ultimately increase our ability to respond to our customers' needs and requirements. A description of our proposed reorganization is included within.

Recently we have begun to forge closer inter-Center partnerships and collaborate with industry and academia. This has positioned the Mission Services Program to deliver more responsive solutions for current and future customers. We have strengthened our technology and upgrades programs in partnership with the Space Operations Management Office (SOMO) and the Applied Engineering and Technology Directorate (AETD). We have provided significant input into the SOMO Commercialization Plan and Implementation Strategy, and initiated the long-awaited transition to commercial service providers. Our experience supporting near-Earth projects has enabled us to contribute significantly to L1, L2, and other Deep Space communications initiatives in partnership with the Jet Propulsion Laboratory (JPL) and Johnson Space Center (JSC). Together with the Systems Technology and Advanced Concepts (STAAC) Directorate, we are studying the telecommunications infrastructure for the Mars Exploration Program. Strong partnerships such as these will enable us to continue to influence mission success.

I am proud of our outstanding safety record! NASA is committed to protecting the safety and health of the general public, the NASA workforce, and our assets on and off the ground. Our record is not only a demonstration of our commitment to safety, but also our commitment to uphold NASA's values. Every project and initiative our organization undertakes considers safety first!

Our role in the space community is evolving. I am confident that our proposed organizational structure and our continued partnerships will enable us to play a valuable mission-enabling role for NASA in the coming years.

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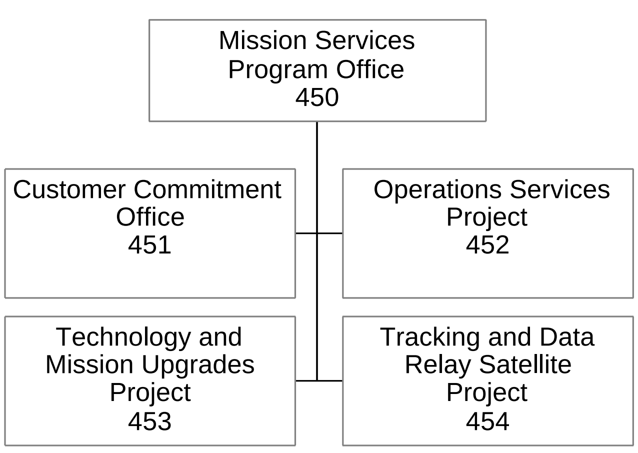
Highlights in This Issue...

In This Issue ...

Mission Services Program Elements

Mission Services Program Proposes Reorganization

The Mission Services Program has proposed transitioning to an organizational structure that will provide numerous benefits to its customers and staff. The proposed organization, as shown in the figure below, is aligned with the SOMO organizational structure. Its focus on the customer interface function will help enable early mission involvement, and improve the qualitative service provided to customers. The proposed reorganization also focuses on technology and upgrades. This will allow the organization to maximize opportunities to insert new technologies and operations concepts in a timely, cost-effective fashion. The proposed reorganization positions the organization for a leadership role in implementing the strategic direction of the Agency. We anticipate the approval of the reorganization within the next month. Once approved, a rapid transition is anticipated. If approved, details of the reorganization will be included in the next edition of the Integrator.



Proposed Reorganization of the Mission Services Program Office

Ground Network Readies for Upcoming EOS Mission Support

The Ground Network (GN) and related Earth Science Data Information System (ESDIS) systems are nearing completion for support of the upcoming Earth Observation System (EOS) missions. The Alaska Ground Station (AGS) and the Svalbard Ground Station (SGS) have been equipped with RF and data systems that enable the stations to support the early series of EOS missions (QuikSCAT, Landsat-7, and Terra). The recent addition of new bit synchronizers, test modulators, and data quality monitoring systems now enable the stations to support the upcoming Aqua, Aura, and EO-1 missions. Development of a 40 Mbps bit synchronizer is underway for the ICESat mission, with delivery of the first unit to the Compatibility Test Van scheduled for late October 2000. Final units are to be delivered in January 2001 for ground station testing.

The EOS Data and Operations System (EDOS) Ground Station Interface Facility (GSIF) has been installed at the SGS and at the Gilmore Creek NOAA facility in Alaska. In addition, the EOS Real-time Processing System (ERPS) has been installed at the SGS, AGS, Wallops Ground Station (WGS), DataLynx, and Kongsberg-Lockheed Martin (KLM) sites. These installations complete the ground systems required to support the EOS mission data processing requirements at the GN stations. The GSIF provides short-term data capture and quality checks. The system provides rate buffering of the 150 Mbps science data to allow data transmission using commercial communications services. The system processes, records, stores, and forwards high rate science data to the EDOS Level Zero Processing Facility (LZPF), and confirms data capture by the LZPF before the stored data is discarded. This action protects against data loss during transmission from the ground station locations to the LZPF (located at GSFC). The EDOS LZPF controls GSIF and ERPS operation independent of the polar ground stations' operational activities. Checkout of the Norway and Alaska GSIF systems was recently completed. The communications links between the GSIF and the EDOS LZPF have also been established.

Other activities at the polar ground stations include ongoing data flow testing for the upcoming EO-1 mission, and planning for a comprehensive series of tests by the ESDIS Mission Readiness Test Team for the Aqua mission. The

Aqua test series will validate the full set of system requirements, and validate system readiness for mission support. X-band data tapes containing Aqua science data have been prepared and will be sent to the SGS for playback from the station's Ampex recorder in November 2000. These tests will confirm the functionality of ground station equipment and the EDOS GSIF to LZPF systems.

All Ground Network systems are ready to support the EO-1 mission (launch readiness date: November 16, 2000) and the Aqua mission (launch readiness date: July 12, 2001).

By Mark Burns/ITT Industries

For more information on this topic, please contact Steve Kremer via email at steven.e.kremer.1@gsfc.nasa.gov or via telephone at (757) 824-1114.

Pacor Automation System Begins Development and Testing

The Sensor Data Processing Facility (SDPF), located in Building 23 at the Goddard Space Flight Center, is involved in the development, integration, and testing of a new level zero data processing system. The Pacor Automation (Pacor-A) system will provide level zero data processing and related services for the UARS, TRMM, HST, and ERBS spacecraft. Services are currently supplied to these missions by the Pacor II Data Capture Facility (DCF), the TDRSS Interface Preprocessor Into Telops (TIPIT) and Level Zero Processing (LZP) systems, the Data Distribution Facility (DDF), and the Generic Block Recording System (GBRS) and Generic Recording System (GRS) systems. These systems are costly to operate because they are aging, have expensive custom front-end hardware, and are manually intensive to operate.

The Pacor-A system will reduce the cost of providing level zero processing services to legacy missions, and provide the basis for level zero processing services for future missions. This feat will be accomplished by consolidating the operations of the aforementioned systems, automating their functions, and eliminating the custom hardware and dated computer systems currently in use.

Pacor-A will consist largely of commercial off the shelf (COTS) and government off the shelf (GOTS) software components, and COTS hardware components. Software modifications to the customer interface will allow the use of common security methods, and provide a common "look and feel," whether customers are on site or remotely located. NISN data services will provide for the routing of the input science data to Pacor-A. Data distribution to remote customers will be accomplished using Internet Protocol (IP) based transfers.

The Pacor-A system is currently undergoing development and testing with an anticipated transition to operations during the summer of 2001. Common portions of the system are now being system tested to verify data capture and archiving requirements. With the implementation of the Pacor-A system, the SDPF will continue to offer cost-effective level zero processing and distribution services to its many customers.

By Brian Repp/HTSI

For further information, please contact the author via telephone at (301) 286-3699 or via email at Brian.D.Repp.1@gsfc.nasa.gov.

White Sands Complex News

Projects Transition to CSOC

Four recently completed White Sands Complex (WSC) projects have been successfully transitioned to the Consolidated Space Operations Contract (CSOC) for operations, maintenance, and sustaining engineering. First, the Ground Network (GN) mode command project adds the capability to provide subcarrier and direct phase-modulated signals to customer spacecraft via the S-band Single Access (SSA) forward service. This service has been successfully provided to the Far Ultraviolet Spectroscopic Explorer (FUSE) program, and is planned for several other missions.

In addition, responsibility for the virtual spacecraft project has transitioned to CSOC. This project allows two customers—one S-Band and one K-Band—to share a single access antenna. So far, the International Space Station (ISS) and Space Shuttle programs are utilizing the virtual spacecraft service. CSOC personnel have also assumed responsibility for the SNIP PN Interoperability project, which allows Space Network (SN) customers to choose from NASA, the European Space Agency, or NASDA PN code libraries. Finally, the WSC Alternate Resource Terminal (WART) is now maintained by CSOC (see article on page 6). Since 1999, WART has been providing telemetry, tracking, and command for TDRS-1, and customized customer support (connectivity to the Internet and data file transfer capability) for the National Science Foundation's South Pole Station.

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Data Services Management Center (DSMC)

The goal of the DSMC project is to relocate systems from GSFC and Wallops to the WSC, consolidating SN and GN operations at White Sands. New systems are being developed and fielded at WSC for SN and GN service accounting, and for GN web-based scheduling. When this project is complete, cost savings will be realized due to staffing reductions. The DSMC is a CSOC Integrated Operations Architecture (IOA) initiative approved by the SOMO on October 5, 2000. The DSMC is expected to be completed in September 2002. For more on the DSMC implementation, see the NCC articles on pages 6 and 7.

Data Services Automation (DSA)

The DSA project consists of software and hardware changes at White Sands that will enable cost savings by combining two operations personnel positions in the TDRSS Operations Control Center. This CSOC IOA initiative was approved by the SOMO on September 21, 2000, and is expected to be completed in June 2002.

Ka-Band Transition Product (KaTP)

The KaTP consists of software modifications to the WSC and the Network Control Center (NCC), and hardware/firmware modifications at WSC to implement an intermediate frequency (IF) service for the 650 MHz channel available on TDRS H, I, J. The project also includes a GN demonstration terminal, and customer simulation and data processing components intended to demonstrate both SN and GN services at rates of 600 Mbps and up. This project will enable customers to use the TDRS H, I, J wide-band Ka-Band channel. This NASA/GSFC initiative was approved by the SOMO on April 5, 2000, and is expected to be completed in December 2001. Read more about this initiative on page 20 of this issue.

Demand Access System (DAS)

The DAS project involves the augmentation of the Multiple Access Return (MAR) system with new beam-formers, receivers, and associated control, monitor, and data distribution systems. This project will increase MAR capacity, and enable a new sub-type of SN service. DAS is a NASA/GSFC initiative approved by the SOMO on March 2, 2000. DAS is expected to be completed in April 2002. Project documentation is available online at *http://stelwscpo.gsfc.nasa.gov/Das/default.htm*, and an article containing further information about DAS is located on page 22.

By Douglas Perkins/ATSC/WSC Training

For more information, please see the WSC Project Office home page at http://wscproj.gsfc.nasa.gov, or contact Jim Gavura, Station Director, or Bryan Gioannini, Deputy Station Director, at (505) 527-7000.

WSC Alternate Relay Terminal Operations Transitions to CSOC

The White Sands Complex (WSC) Alternate Relay Terminal (WART) continues to provide Internet connectivity and high speed file transfer services to the South Pole [using the South Pole TDRSS Relay (SPTR)] for just under five hours a day. The WART Transition Readiness Review (TRR) was held on September 28, 2000. CSOC has assumed all operational and sustaining engineering responsibilities for the WART hardware at WSC. On-site training will be held in early November to enable the transition of WART software sustaining engineering and SPTR operations responsibilities to CSOC.

For more information on WART, contact Dave Israel/GSFC Code 567.3 at (301) 286-5294, or via email at dave.israel@gsfc.nasa.gov.

Network Control Center News

The Network Control Center (NCC) has several ongoing Data Services Management Center related activities and significant operational accomplishments to report for this issue of *The Integrator*.

Since June 1, 2000 the NCC supported seven ELV Launches and two Space Shuttle missions.

The Communications and Control Segment Replacement (CCSR) hardware has arrived at the NCC. The vendor is scheduled to install the equipment the week of October 16. The current CCS system will be re-hosted on newer hardware in preparation for the transition of NCC operations to the White Sands Complex (WSC).

This transition of NCC operations to WSC (known as the Data Services Management Center effort or DSMC) will consolidate Space Network (SN) and Ground Network (GN) operations at the WSC. NCC Operations personnel continue to work with WSC staff on the Technical Manager (TM) and Performance Analyst (PA) tasks that have moved to WSC during phase one of the DSMC transition. Operations staff provided an updated contact list including phone numbers for NASA points-of-contact for customer or Network anomalies. The DSMC is scheduled to be complete in Spring of 2002.

NCC Operations and Database personnel supported the NCCDS software delivery on July 17. Operations personnel coordinated all of the delivery timeline activities with the developers and Operations Engineers. Database staff also took the opportunity during the downtime to update the Firewall to include IP addresses for several of the backup Small Conversion Devices (SCDs) that were not previously allowed. They also completed DCN-01 to the Firewall Users Guide, which specifies step-by-step procedures required to make Firewall database updates. Database staff also provided support to the Schedulers following the Maintenance Release 2 (M00.2) delivery to make sure the parameters for the Schedule Transmission Rules Sets were the same as before the delivery.

TDRS-H successfully launched on June 30, 2000. Operations and Database personnel have since then participated in TDRS-8 Level 6 testing. Database staff have received and processed several requests from customers to generate new operational codes for TDRS-8 support. Customers have scheduled TDRS-8 events to verify there are no problems with the scheduling functions and to verify all necessary database updates are complete. Customer end-to-end testing with TDRS-8 is ongoing.

As per Network Advisory Message (NAM) 470, the following changes took place for the Scientific Customer community on June 30, 2000:

1. The WSC Operations Supervisor replaced the NCC Technical Manager as the central point of contact for SN Operations.

2. Customers will now contact the WSC CSC position (call sign CSC-1 through 6) on the current voice scamas for the following:

- Coordination of all SN troubleshooting activities including WSC systems problems and NISN connectivity problems.
- Coordination and transmission of all contingency GCMRs.
- Generation of all SN related TTRs. TTRs will remain available on the NCC Web page for customer view.
- Restoration of User Performance Data (UPD) and line connectivity between the MOC and the NCCDS. Conduct of all pre-pass and post-pass briefings, as required.

3. The WSC Site Specialists (call sign STGT OPS or WSGT OPS) will coordinate all playback voice interfaces. Customers will continue to contact NCC Scheduling to coordinate playbacks.

The Wallops Scheduling Office assumed GN scheduling and reporting responsibilities for the Merritt Island/Ponce de Leon and Bermuda stations as of Monday, June 12.

By Joe Snyder/ATSC

For further information, please contact Bill Webb/GSFC Code 451 at (301) 286-3264 or visit http://ncc.gsfc.nasa.gov on the World Wide Web.

NCCDS Maintenance Status and Future Plans

After a slight delay caused by activities such as the TDRS H launch, the second Maintenance Release of NCCDS 98 (dubbed Release M00.2) successfully transitioned into Operations in July. This release is the major component of the NCCDS maintenance effort. The contents of this release includes solutions to 150 problem reports and 24 NCC Change Requests (NCRs). Release M00.2 included major redesigns of Wait List Processing, TDRS Mapping changes, and processing of requests off of the autoqueue. This release also included performance and functionality improvements—like on demand list sorting by column—for many of the operator windows. M00.2 also contained the NCCDS changes for the final phase of the Space Network Interoperable PN Code Libraries implementation.

Development of the Third Maintenance Release, M00.3, is complete, and that release has just transitioned into the Operations Evaluation Testing (OET) phase. This transition was delayed due to support of engineering interface tests requested by external customers. With this schedule change, M00.3 is now targeted to transition into Operations in early January 2001. To date, the content of this release, which can be reviewed at *http://ncc98.gsfc.nasa.gov/bld-cont/m003.stm*, includes solutions to over 80 problem reports and 14 NCRs. One of these NCRs documents the software changes needed to implement NCCDS support of Ka-band Wide Band (i.e., 650 MHz) services. These services are part of a demonstration of the capabilities of Ka-band services for both the Space Network and the Ground Network. The M00.3 changes will allow Ka Wide Band services to be defined in the database, scheduled, and transmitted to the

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ground terminals and the Mission Operations Centers (MOCs). The second part of this implementation (i.e., the real-time monitoring and control of Wide Band services) will be completed in a follow-on release.

The NCCDS continues to prepare for its move to the White Sands Complex (WSC) to become the major component of CSOC's Data Services Management Center (DSMC). As part of this preparation, the Communications and Control Segment (CCS) and the NCC Test System (NTS) are being rehosted on more appropriate hardware platforms.

The CCS Rehosting effort will replace the current VAX 8550 platform with a VAX 6610, which is a platform more compatible with the existing WSC VAX equipment. With the very recent arrival of the still "shrink-wrapped" hardware, this effort will be in full swing by November.

The NTS Porting effort is similar in purpose to the CCS Rehost; that is, migrate to a platform that is more effective for the DSMC. In this case, the platform is more effective because it is more modern. This effort, however, also will infuse some new technology into the NTS—the ported NTS will have a new JAVA operator interface. Several components of this activity are now well underway, although the target hardware has not yet arrived.

The influence of the DSMC efforts and other activities and initiatives will limit the scope and duration of future endeavors for the NCCDS. Therefore, the future plans for the NCCDS will be very dynamic.

By JR Russell/CSC

For more information about the NCC maintenance releases, please contact Roger Clason at (301) 286-7431.

TDRS-8 Is Up and Running!

TDRS-8 is currently undergoing extensive acceptance testing at 150 degrees West Longitude. As part of the acceptance testing, approximately 100 customer target-of-opportunity (TOO) events were successfully supported by the new spacecraft. ECOMM, EUVE, ESTL, FUSE, HST, Landsat-4, STS-106, TERRA, TOPEX, and RXTE participated in the TOO testing, executing S-band Multiple Access (SMA), S-band Single Access (SSA) and Ku-band Single Access (KuSA) telemetry and command events, including tracking services. Engineers are now investigating performance issues of TDRS-8's Multiple Access return service. After acceptance testing is successfully completed, the performance of TDRS-8 will be further evaluated by characterization testing, STS and ISS testing, and additional target of opportunity tests before it is moved to 171 degrees West and placed into operations.

User Planning System Operational with Flexible Scheduling and TDRS-8 Services

The multi-mission User Planning System (UPS) is now operational, supporting its customers (RXTE, TRMM, UARS, ERBS, and EUVE) with flexible scheduling capabilities and TDRS-8 support. Although only the RXTE mission has updated its ground system to enable use of the TDRS-8 S-band Multiple Access (SMA) service, the UPS supports all TDRS-8 services (SMA, Ka-band Single Access and Ka-band Single Access WideBand).

In July, the Hubble Space Telescope project deployed the UPS Release 12, and became the first customer to submit flexible schedules to the NCC on an operational basis.

The Mission Control Center at Johnson Space Center, supporting both the Space Shuttle and the International Space Station, is planning to transition its UPS from Release 11 to Release 13 later this year.

By Howard Michelsen/CSC/CSOC

Further information regarding the UPS Project can be found on the WWW at http://isolde.gsfc.nasa.gov/ups/ or contact the author via email at hmichels@cscmail.csc.com.

Mission Services Program Customers

Expendable Launch Vehicle Support Update

The Sea Launch Program has returned to launch operations with the successful launch of PanAmSat-9 on July 28, 2000. Sea Launch also launched the THURAYA payload on October 21. One additional launch is planned in December. On June 26, Sea Launch signed a contract with Space Systems/Loral to launch the Telstar-9 satellite in 2002. Other launches of note during the past few months include the launch of Atlas 2A/TDRS-H, Atlas 2AS/EchoStar-6 and Pegasus/HETE-2.

The Boeing Delta IV and NASDA H-IIA programs continue to progress towards their initial launches. Boeing completed Delta IV solid rocket motor qualification testing in June of this year. On September 11, the $27 million Delta IV rocket-processing plant at Cape Canaveral Air Force Station was dedicated. This facility will be used to prepare Delta IV rockets for launch from nearby Space Launch Complex (SLC) 37. SLC 37 supported unmanned Apollo launches from 1964 to 1968 and was deactivated in 1972. Network personnel will get a first hand look at the Boeing Complex in early November when they attend the Third Technical Interchange Meeting which is being held there.

Following a successful meeting with NASDA personnel in June, a second Technical Interchange Meeting was held at Goddard on October 26. NASDA has been through a review process since our last meeting and is anxious to begin work on efforts to have Space Network support the H-IIA launch vehicle, and their efforts to send the Selene vehicle to the moon in 2003. Selene will be launched from the Tanegashima Space Center in Japan.

By Joe St. John/CSOC/GSFC Code 451

For further information, please contact Ted Sobchak/GSFC at (301) 286-7813, or via email at Ted.Sobchak@gsfc.nasa.gov

TRACE Helps Explain Sun's Heating System

Images from NASA's Transition Region and Coronal Explorer (TRACE) spacecraft recently enabled scientists to shed some light on an interesting solar phenomena—the extreme temperatures found in the sun's corona. The sun's core temperature is approximately 29 million degrees Fahrenheit. As temperature measurements are made further and further from the core, the temperature decreases, for example, to 10,000 degrees on the "surface" of the sun. Surprisingly, however, temperatures begin to rise again (to between three million and twenty million degrees) in the sun's outer atmosphere. This odd temperature gradient has puzzled scientists for years.

During the latest solar maximum, instruments on TRACE (a GSFC Small Explorer mission) provided detailed images of the loops that make up the sun's corona.

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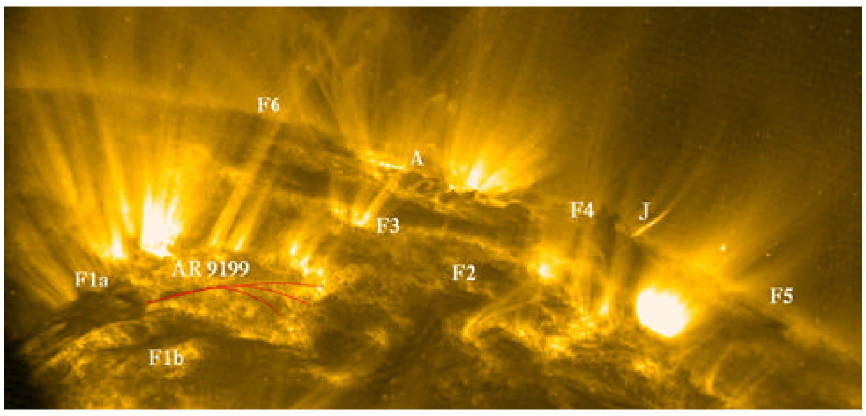

This image of the northeastern solar limb (north is to the right) was taken by TRACE on 17 October 2000, at 03:39UT in the 171A passband, showing emission from gas at approximately 1 million degrees. In the lower-left corner is Active Region 9199, with a double filament (F1) reaching across it. There are at least five other filaments (F) in this image, plus a dark, cool arcade of loops (A), and a short-lived jet (J).

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These images allowed scientists to deduce that the source of the intense heat is located at the bottom of these electrified coronal loops. Investigators now believe that the loops are not evenly heated static structures (as once thought) but consist of filaments containing incredibly fast moving gas that is constantly refilled from sources below.

It is important for us on Earth to understand the sun's coronal behavior, because the earth is directly in the path of the solar wind. Abrupt increases in solar activity have the power to disrupt the many communications systems which we have become so dependent upon in the last several years. Using instruments such as those on TRACE, scientists hope to one day gain the ability to accurately predict the sun's activity, therefore enabling us to take preventive measures here on Earth.

Information in this article was obtained from an article by Kathy Sawyer in the September 27, 2000 edition of The Washington Post.

For further information about satellites in the SMEX Program, please contact Patrick Crouse at (301) 286-9613.

Landsat-7 Mission Continues

NASA turned Landsat-7 (L-7) operations over to the U.S. Geological Survey (USGS) on October 1, 2000. Spacecraft and instrument operations, data capture, processing, and distribution are now managed by the USGS's EROS Data Center (EDC) in Sioux Falls, South Dakota. NASA continues to be part of the joint program by providing spacecraft anomaly support and ground network coordination through the Earth Science Mission Operations Project (GSFC Code 428) and instrument calibration and data quality assessment support through the Landsat Project Science Office (GSFC Code 923).

L-7 was launched on April 15, 1999 and entered the operational mode on July 15, 1999. Its orbit is sun-synchronous at approximately 10 a.m. on the Landsat World Wide Reference System ground track. Scenes are acquired in a 16-day repeat cycle, 8 days out of phase with Landsat-5. All U.S. L-7 data are either acquired at, or shipped on tape to EDC for processing, archiving, and distribution. In addition, agreements are in place enabling EDC to directly downlink data to International Cooperators (ICs). Presently, L-7 data are being downlinked to twelve stations belonging to six ICs. Two more stations will be added in the near future—one in Indonesia and one in Brazil.

L-7 has been supporting a number of scientific campaigns. One example is the SAFARI 2000 experiment that observed fires in southern Africa, investigating their contribution to atmospheric and environmental conditions. This effort involved coordinated ground, air, and space measurements conducted over areas of prescribed burns. The satellite was programmed to acquire images over specific areas at the same time that data were being taken by aircraft overflights and field measurements. Levels of carbon and other particulates in the air as a result of different fires (wildfires, prescribed agricultural burning, cooking, heating, and charcoal-making) are being studied in terms of their contribution to the overall ozone depletion problem.

This summer, L-7 was involved in a program monitoring sea ice melting in the Beaufort Sea, and provided images of natural and man-made disasters (floods, volcanic eruptions, fires, hurricanes, and tornadoes) to governments and relief organizations. Preparations are underway to complete imaging of Antarctica during its summer. This will include re-imaging areas acquired last year during periods of excessive cloud cover.

The L-7 satellite continues to perform its primary mission of acquiring, processing, and archiving images, per its Long Term Acquisition Plan, to perfection. As of mid-October, approximately 105,000 full images have been placed in the U.S. archive at EDC and another 140,000 images have been downlinked to the ICs.

By Ken Dolan/GSFC Code 428

To learn more about the Landsat program or to view or purchase images visit the Landsat web site at http://landsat7.usgs.gov.

EUVE Marches On, but the End Draws Near

While the roll-over to the Year 2000 ushered in the dawn of a new century, it has also inaugurated the dusk of the EUVE mission. Things started off well with the very smooth transition past the dreaded Y2K barrier. Our hats are off to all EUVE Project personnel—both to the operations team at the University of California at Berkeley (UCB) and to the various support personnel at GSFC—who worked very hard to make Y2K a nonevent for EUVE. Then, in March the Project celebrated its third year of outsourced spacecraft operations at UCB, which was followed in June by the eighth anniversary of the EUVE launch. Also in June, the

EUVE team at UCB received a Public Service Group Achievement Award from NASA Administrator Daniel Goldin, rewarding the team for its continued innovative efforts to streamline and automate mission operations.

But all news in 2000 was not good news. In August NASA Headquarters informed the Project of NASA's intent to terminate the EUVE mission at the end of 2000. Because of the continued health of the EUVE satellite and uniqueness of its scientific data, the EUVE Project and its science customer community appealed this decision, apparently to no avail. Accordingly, the Project has initiated end-of-mission activities with GSFC (see below).

Speaking of unique science, during the past few months EUVE has spawned a number of new and exciting discoveries. For example, Dr. Peter Wheatley (University of Leicester, UK) and colleagues reported that an EUVE target of opportunity (TOO) observation is helping to reveal the stages of optical, x-ray, and EUV emission observed in an outburst of the brightest known dwarf nova, SS Cyg. An analysis of contemporaneous 1996 optical, EUVE, and RXTE observations of SS Cyg show that the outburst starts in the optical band and about a day later moves to the x-ray and the EUV bands as the gas flow reaches the system's white dwarf star (see Figure 1). The so-called "boundary layer" transition between x-ray and EUV has never before been seen, and was only detected due to the combined rapid TOO response of EUVE and RXTE. Detailed study of these data will help reveal the nature of the unstable gas flow in accretion disks.

As a second example, in the Spring EUVE led a mammoth multi-wavelength coordinated observing campaign of the magnetic cataclysmic variable, EX Hya, for Dr. Steve Howell (Planetary Science

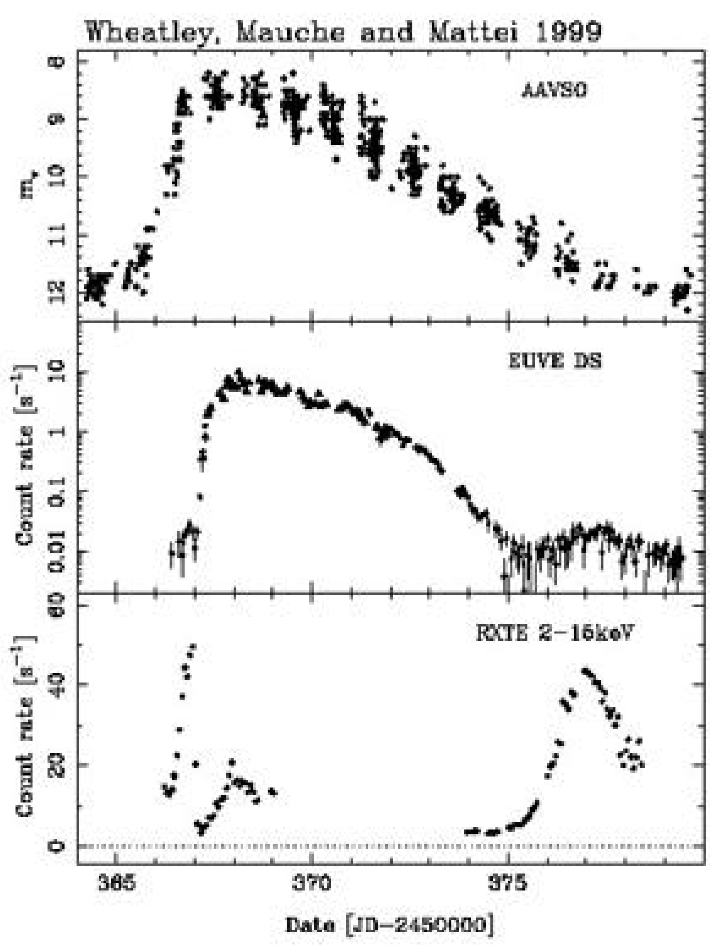

Figure 1: Multi-wavelength coverage of SS Cyg outburst

Institute). For 44 days in May and June 2000, EUVE observed this source for a combined exposure of ~1 million seconds. The very long observing baseline set the stage for and led to the largest coordinated or contemporaneous multi-wavelength campaign ever organized for the study of astrophysical plasma and accretion phenomena. This observing campaign consisted of parallel observations with five other satellites — Chandra, FUSE, HST, RXTE, and the Naval Research Laboratory Advanced Research and Global Observation Satellite (ARGOS), as well as with 14 ground-based telescopes. A detailed press release on this observing campaign is available at *http://www.space.com/scienceastronomy/astronomy/binary_star_search_000502.html*

The scientific results represent the best spectrum of an interacting binary yet obtained by EUVE (see Figure 2). Initial analyses of this spectrum show over 30 emission lines due to highly ionized iron and neon. These data will allow researchers to determine the temperature and density of the system's emitting plasma, on spatial scales equal to 20% of the radius of the system's white dwarf primary star (~1000 miles). Details on past and present EUVE science highlights are available on-line at *http://www.cea.berkeley.edu/~science/html/Resources_high.html*

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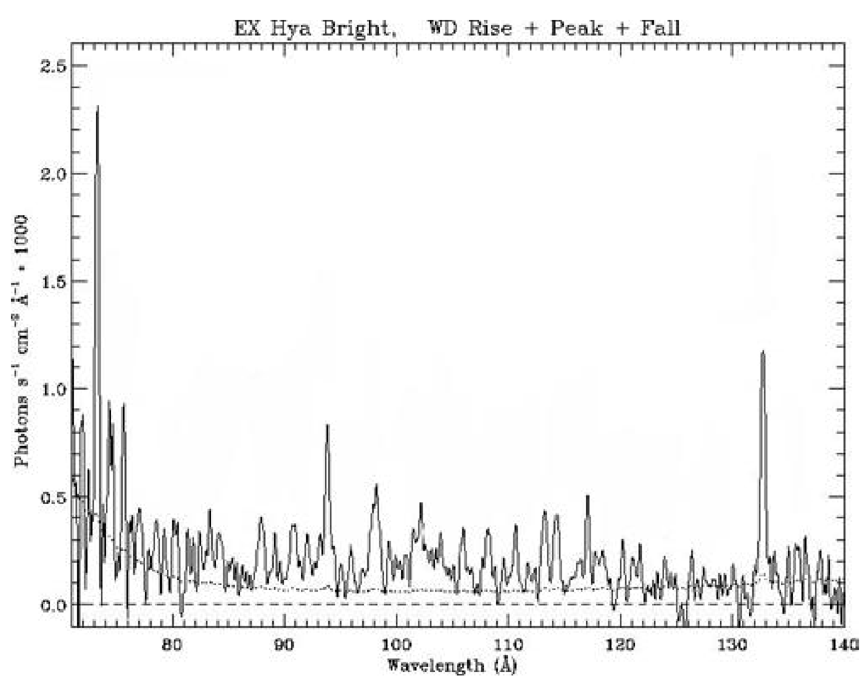

Figure 2: ~1 million second EUVE short-wavelength spectrum of EX Hya

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These and other EUVE scientific results were well represented at the January and June meetings of the American Astronomical Society; in fact, a specific EUVE science session was held at the latter meeting. Additionally, a recent survey of active EUVE observers showed them to be very satisfied with EUVE observing services, and they generally ranked their EUVE experiences above those of other missions with which they had observed. The EUVE Project at UCB takes great pride in these results, especially considering the Project's shrinking staffing and funding levels over the past few years.

EUVE mission operations continue to be challenging and exciting for the UCB team. During the first nine months of 2000 EUVE carried out observations of 27 individual celestial targets through over 220 separate spacecraft pointings. Four of these observations were TOOs, and 11 were coordinated with one or more of Chandra, FUSE, HST, RXTE, and other space- and ground-based observatories. A couple of these observations were of special interest and challenge from an operational viewpoint. For the 500 ksec April observation of the Virgo cluster of galaxies, the FOT performed 50 separate pointings with the spacecraft, alternating at 10 ksec intervals first "on" source and then "off". And in June, the EUVE observation of the Comet LINEAR required 180 separate pointings, two per orbit, along with special "escape" slews (i.e., to ensure instrument sun-safety during orbital day) and other unique configurations.

As usual, however, there have been a few interesting instrumental anomalies so far this year. First, two minor anomalies occurred on the science payload. In January one of the analog-to-digital converters locked itself up into a strange state, which prevented the proper processing of photon information from one of the telescopes. In October an apparent single-event upset caused a reset to one of the telescope interface units.

Secondly, on the spacecraft end there were a number of interesting anomalies. Most were minor, including anomalies related to the high-gain antenna (HGA) gimbals, the on-board ephemerides, and the on-board computer's power monitor (PMON) processor. However, EUVE also had a few major anomalies that caused the spacecraft to enter safe-hold mode (SHM) on three occasions. The first SHM event occurred in February when the HGA gimbals overheated due to incorrect pointing because of a bad gimbal table load. Then, on 16 May EUVE entered SHM again when the load bus voltage dropped too low, a result of the ongoing degradation of one of the EUVE batteries. And, only three days later, on 19 May, that troublesome battery finally failed completely when it shorted out and triggered another SHM transition.

None of the above anomalies posed any real threat to the overall health of the satellite. All were quickly detected by UCB's ground-based telemetry monitoring software, which then triggered pages to FOT engineers who rapidly identified, diagnosed, and appropriately responded to the problems. Even including these anomalies, overall EUVE science data return rate during 2000 has continued to surpass 98%.

When not dealing with anomalies, the FOT worked a number of other engineering efforts. First, the above-mentioned failure of one of the three on-board batteries required that all on-board power-related telemetry monitors (TMONs) and relative time sequence (RTS) command macros had to be reworked to reflect two-battery operations. Second, the FOT supported a number of tests with EUVE on the newly-launched TDRS-8 satellite; these tests successfully made use of both the SSA and new SMA antenna services on TDRS-8. Finally, the FOT has continued to network with the engineering community to discuss mission operations automation. Over the past nine months the FOT has hosted in the EUVE control center a visitor per month on average, representing commercial (e.g., Globalstar), military (e.g., Shreever Air Force Base) and traditional NASA (e.g., Gravity Probe B) missions.

Last but certainly not least, in response to NASA's decision to terminate EUVE, the Project has sadly begun working with GSFC to plan end-of-mission activities. GSFC and JSC completed an orbital debris study that indicated that EUVE's re-entry "footprint" of 6 square meters falls under the NASA guideline (8 square meters). EUVE will then be left to re-enter the earth's atmosphere in an uncontrolled fashion on its own; according to recent predictions, this will likely take place in early Spring 2002. UCB and GSFC are now planning the end-of-mission activities, including end-of-life tests on the satellite systems. EUVE mission operations are scheduled for termination at the close of 2000. It will be a bittersweet end for EUVE—we had hoped to continue its operation until re-entry. However, everyone who supported the EUVE mission—from conception through development, launch, and on-orbit operations—should be proud of his or her contribution to this highly successful NASA mission. And for the EUVE operations team at UCB, the mission has been a true labor of love, one to which we will soon bid a sad but grateful farewell.

Article by Brett Stroozas/EUVE Project/Mission Manager

For more information, please visit the UCB/CEA WWW site at URL http://www.cea.berkeley.edu, or contact the author at (510) 643-7312 or via e-mail at bretts@cea.berkeley.edu.

Tropical Rainfall Measuring Mission: Autumn 2000 Status

The Tropical Rainfall Measuring Mission (TRMM) spacecraft will attain its third operational anniversary on 27 November 2000. At that time, TRMM will have achieved over 17,000 orbits, continuing to augment its valuable science data set. Many people—scientists and laymen alike—use the science products generated from TRMM. TRMM will begin its Extended Mission phase on 01 January 2001, and NASA has recently approved continued funding through 2003. Therefore, the mission is expected to continue as long as safety considerations and fuel reserves allow.

TRMM's third passage through the Leonid meteor storm will occur in mid-November. With its instruments powered off, TRMM weathered past storms without mishap.

Since July 2000, we have convened monthly meetings to discuss mission end-of-life scenarios and the means to safely conduct re-entry for TRMM, should the need arise. These meetings came about after the CGRO spacecraft's controlled re-entry in late Spring. The safety factor is again paramount when weighed in conjunction with science data collection.

During the nighttime hours of 16-17 September the spacecraft suffered a loss of science data after a power system telemetry box experienced an anomalous condition. Erroneous telemetry initiated the load shedding of all instruments from the spacecraft Non-Essential Bus, after TRMM was forced into Low Power mode at 062340z on 17 September. Science data collection ceased until the latter hours of the September 18, as AETD engineers and supporting groups worked to understand the problem. The spacecraft, however, always remained power positive while in Low Power mode, and both batteries continued to function nominally. Anomaly analysis continues and alteration of some of our operational methods are being completed. It should be noted that at no time during this anomaly were spacecraft attitude or communication in jeopardy; both functioned properly throughout.

By Lou Kurzmiller/TRMM FOT

For additional information, please visit the TRMM web site at http://trmm.gsfc.nasa.gov, or contact John Grassel/ ATSC by telephone at (301) 805-3167 or via email at john.grassel.1@gsfc.nasa.gov.

The Compton Gamma Ray Observatory Mission: A Retrospective View

The Compton Gamma Ray Observatory was the second of NASA's Great Observatories. Compton, at 17 tons, was the heaviest astrophysical payload ever flown at the time of its launch, on April 5, 1991, aboard the space shuttle Atlantis. Compton hosted four instruments that covered an unprecedented six decades of the electromagnetic spectrum, from 30 keV to 30 GeV. In order of increasing spectral energy coverage, these instruments were the Burst And Transient Source Experiment (BATSE), the Oriented Scintillation Spectrometer Experiment (OSSE), the Imaging Compton Telescope (COMPTEL), and the Energetic Gamma Ray Experiment Telescope (EGRET). For each of the instruments, an improvement in sensitivity of better than a factor of ten was realized over previous missions. The

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Observatory was named in honor of Dr. Arthur Holly Compton, who won the Nobel prize in physics for work on scattering of high-energy photons by electrons—a process which is central to the gamma-ray detection techniques used by all four instruments.

Many exciting discoveries were made by the instruments on Compton, some previously expected, and some completely surprising. The all-sky map produced by EGRET is dominated by emission from interactions between cosmic rays and the interstellar gas along the plane of our Galaxy, the Milky Way (Figure 1). Some point sources in this map are pulsars along the plane. Seven pulsars are now known to emit in the gamma-ray portion of the spectrum, and five of these gamma-ray pulsars were discovered since Compton was launched. All four CGRO instruments have made valuable contributions to the study of pulsars.

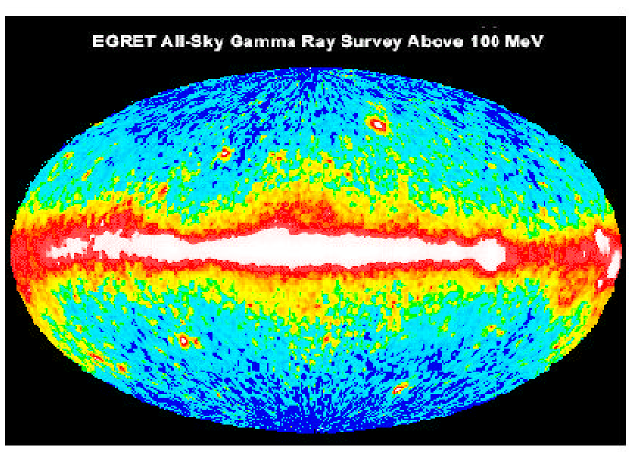


Figure 1. A map of the sky measured with the EGRET experiment. The concentration towards the horizontal, central region of the map is the plane of our Galaxy. That enhancement is due to the interaction of cosmic rays with the interstellar medium, as well as from unresolved point sources, such as pulsars.

An all-sky map made by COMPTEL illustrates the power of imaging in a narrow band of gamma-ray energy—the light of radioactive aluminum 26 (Figure 2). This map reveals unexpectedly high concentrations of this particular isotope in small regions. Supernova or massive, evolved stars are the likely sources of the 26-Al. The spatial and intensity distributions of this radioactive emission have major implications for the chemical evolution of our Galaxy, since the 26-Al isotope has a decay-half lifetime of about 1 million years. This information thus provides a 1-million year historical record of nucleo-synthesis activity.

In another map of the Galactic center region, scanning observations made by OSSE reveal gamma-ray radiation from

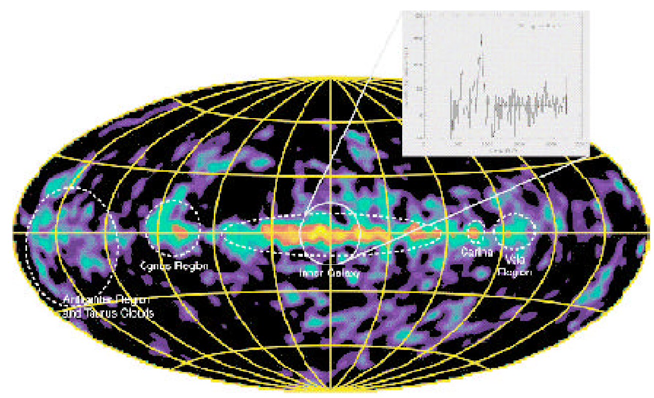


Figure 2. COMPTEL all-sky map of radioactive emission of from 26-aluminum. The inset shows a corresponding gamma-ray spectrum, illustrating the sharp peak at the 1.8 Mev

the annihilation of positrons and electrons in the interstellar medium. Prior to CGRO, this electron-positron annihilation radiation was believed to be of variable intensity, and to emanate from a compact region. OSSE has revealed the extended nature of this emission, as well as a possible north-south latitude asymmetry (Figure 3). This data has been interpreted as evidence for a previously unknown period of intensive star formation activity in the central region of our Galaxy.

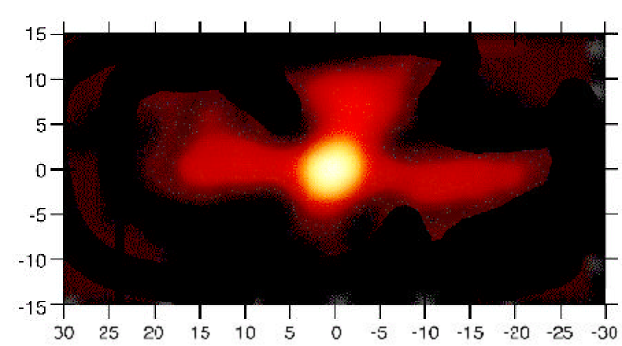


Figure 3. OSSE map of the Galactic center region. The emission is clearly extended, and there is evidence for a north-south latitude asymmetry.

One of BATSE's primary objectives was the study of the mysterious phenomenon of gamma-ray bursts—brief flashes of gamma rays which occur at unpredictable locations in the sky. BATSE's all sky map of burst positions shows that, unlike Galactic objects which cluster near the plane or center of the Galaxy, the bursts are distributed isotropically over the entire sky. (Figure 4). It is now known that the gamma-ray bursts originate at great distances (billions of light years) from our Galaxy, probably in star-forming regions of young Galaxies.

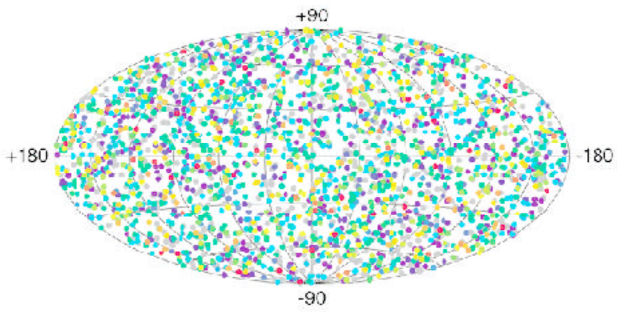


Figure 4. BATSE map of over 2700 gamma-ray burst positions recorded during the 9-year mission. Prior to CGRO, it was anticipated that the burst positions would be concentrated along the plane of our Galaxy. They were in fact, as is evidenced here, distributed isotropically over the entire sky, indicative of an extra-Galactic population.

After nearly a decade of making highly beneficial observations which enabled numerous scientific discoveries, the CGRO mission came to an end in the early morning hours on June 4, 2000. Engineers at the Goddard Space Flight Center in Greenbelt began planning for the Observatory's reentry back in April 1999, when one of its gyroscopes first began experiencing problems. Although the observatory was still functioning properly and still scientifically productive, a decision was made to follow the path of least risk, which was to perform a controlled reentry maneuver at the earliest plausible time. Thus ended one of NASA's most successful high-energy astrophysics missions.

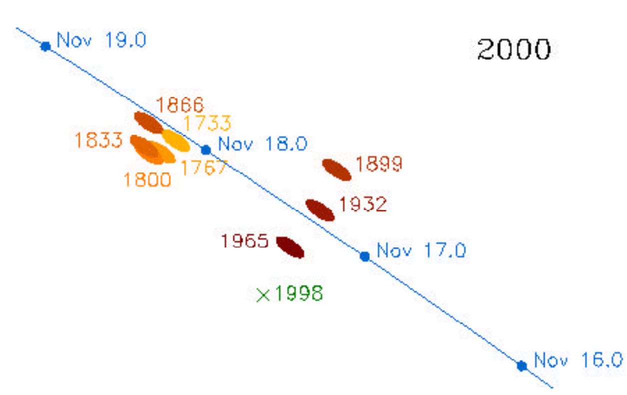
By Dr. Chris R. Shrader/CGRO Science Support Center, NASA/GSFC

For more information on the Compton Gamma Ray Observatory see: http://cossc.gsfc.nasa.gov.

TOPEX/Poseidon Operations Prepares for Incoming Missiles

The U.S.-French TOPEX/Poseidon satellite continues to remain in good health; in fact, the mission celebrated its eighth anniversary this August. Although TOPEX/Poseidon has become well known for providing El Niño and La Niña images of the Pacific, the relatively anonymous operations team at JPL has enabled the satellite to persevere well beyond its three-year design life. In addition to handling the inevitable anomalies and planning problems that all operational teams encounter, proactive actions to prevent and mitigate against these events are also implemented on a regular basis.

A prime example of this "preventive care" on TOPEX/Poseidon occurs each year during a celestial event known as a meteor shower (or storm, depending on the measured intensity). Each November, the Earth encounters space debris as it orbits through the trail of a periodic comet known as Temple-Tuttle. This results in an annual meteor shower called the Leonids—so named because shower activity observed from the Earth's surface appears to originate from the constellation Leo. Temple-Tuttle passes in close proximity to the Earth's orbital plane approximately every 33 years, with the most recent encounter occurring in early 1998. For a year or two following this event, greatly enhanced levels of shower and storm activity have historically occurred. This year, Leonid meteoroid flux densities about the Earth's orbit will peak over two predicted time periods during the 17th and 18th of November. Maximum activity levels are predicted using celestial maps of the earth's orbit relative to the path of previous passes by comet Temple-Tuttle (see graphic).



Armagh Observatory graphic depicts the Earth's orbit on November 16-19 of this year and its relationship to areas of meteroid debris from previous close-proximity passes of comet Temple-Tuttle. Peak shower activity periods will occur when the Earth passes near trails of the 1733, 1866, and 1932 events.

All satellites are exposed to several hazards in space, one of which is the potential for damage from meteoroid strikes. This possibility increases for Earth-orbiting satellites such as TOPEX/Poseidon during meteor showers and storms, when the density of meteoroids near the Earth's orbit rises dramatically over a relatively short time period. Problems encountered can be mechanical in nature, where meteoroid strikes on the satellite structure itself will cause damage similar to the effect that a bullet or non-explosive missile would produce. Somewhat more probable are anomalies electrical in nature, whereby meteoroids disintegrating upon spacecraft impact can generate a plasma plume, which subsequently

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causes electrical shorts or electrostatic discharge (ESD) damage to occur in subsystem circuitry.

Prior to previous Leonid events in 1998 and 1999, the TOPEX/Poseidon flight team evaluated actions taken by other satellite programs during the August Perseid meteor showers in 1993 and 1994, along with the latest meteor storm risk mitigation recommendations from the satellite operations community. We determined the best operational strategies for TOPEX/Poseidon, which primarily included measures to minimize the cross-sectional satellite area exposed to the meteoroid radiant. This was accomplished by aligning the relatively large solar array edge-on to the radiant for several hours, centered about the storm peak. During this time we also powered off our primary payload, which contains a high-voltage power supply that is potentially sensitive to ESD damage. Given predictions that meteoroid levels will be relatively high during this year's Leonid event, these now standard operational precautions will again be implemented on TOPEX/Poseidon during the peak shower activity periods.

The team is confident that these types of preventive measures will allow TOPEX/Poseidon to achieve continued mission success over coming years. Although the satellite is currently operating with several degraded or failed hardware systems, we have been able to substitute redundant components or design operational alternatives in all cases. The Project remains optimistic that the satellite will remain healthy through next year's launch of Jason-1, the follow-on mission to TOPEX/Poseidon.

By Mark Fujishin/Manager, JPL Earth Science Mission Operations

For additional information about TOPEX, please contact the author at (818) 393-0573, or via email at Mark.fujishin@jpl.nasa.gov.

ULDBP Preparing for Flight Again

The Ultra Long Duration Balloon (ULDB) Project (ULDBP) is preparing for the final test before return to flight in January 2001. The purpose of the test is to simulate the ULDB's communications capability via Space Network (SN) forward and return links and to verify the performance of the ULDB's communication via the SN.

The ULDBP supports various scientific experiment campaigns, which vary from flight to flight. The ULDB transmits real-time data via SN Multiple Access at data rates up to 50 kbps. This data is also recorded on board for later recovery or playback during flight. A Single Access event/support would be used to playback recorded and real-time telemetry simultaneously. The S-Band Single Access (SSA) data rate is up to 150 kbps.

ULDB campaigns are flown during two periods of the year. During the Northern Hemisphere summer, flights are launched from North American locations and are circumglobal. During the Austral summer, flights can originate from Australia or New Zealand and be circumglobal, or can drift southward over Antarctica. Flights are generally 60 days in length and are capable of up to 100 days. ULDB missions are capable of supporting scientific observations from altitudes above 99% of the Earth's atmosphere.

The ULDB will use the White Sands Complex (WSC) Transmission Control Protocol /Internet Protocol (TCP/IP) Data Interface Services Capability (WDISC) to receive balloon telemetry and send balloon commands via the Space Network (SN). Balloon missions are controlled from the ULDB Operation Control Center (ULDBOCC) located in the National Scientific Balloon Facility (NSBF) at Palestine, Texas. The ULDBOCC will use the Space Network Web Services Interface (SWSI) demonstration system to schedule and control SN services.

The ULDB Project is managed by National Aeronautics and Space Administration (NASA) Goddard Space Flight Center, code 820, the Balloon Program Office.

By Danh Nguyen / Lockheed Martin

For additional information, check out the web site at http://www.wff.nasa.gov/~uldb/index.html, or Contact Ted Sobchak at (301)286-7813 or via email at Ted.Sobchak@gsfc.nasa.gov.

Ultra Long Duration Balloon utilizing the pumpkin balloon design

Additional Activities

International Space Station Assembly Sequence

Previous editions of The Integrator have reported the progress of the International Space Station (ISS), but none have captured the excitement of recent events. The first two building block components (Russian FGB and the US Node 1) have been on orbit since November/December 1998. The Russian Service Module (SM) launched on July 12, and successfully docked with the FGB. After the SM launch, the build sequence made huge strides in preparation for permanent human presence. Now, much of the initial assembly sequence rests in the hands of the U.S.

Over the next year, a total of 15 ISS Assembly missions are scheduled—nine of which are Space Shuttle missions. These missions include activities from logistical re-supply, to communications equipment transport/activation, to permanent human presence, and installation of the US Lab. On October 30, 2000, the ISS 2R mission is expected to launch. This Russian Soyuz mission will carry the first crew members of the International Space Station. The crew, consisting of Russian Cosmonaut Sergei Krikalav, U. S. Astronaut Bill Shepherd, and Cosmonaut Yuri Gidzenko, has been busy training in Russia.

The ISS is one of NASA's largest endeavors to date. Mission success relies on communications, and ISS communications is dependent on the functionality of the equipment and the ground/space resources provided by the NASA Networks. From the Networks' perspective, ISS Core Systems activation is a major keystone in the schedule to provide command, telemetry, voice, and video for ISS. The Networks have been preparing for core system activation for years. Since 1995, Network teams have been testing with ISS S-Band and Ku-Band equipment [Development, Verification, and Test Model (DVTM), Proto-Flight Model, and Flight Model] to verify Network compatibility. The recent ISS Flight 3A mission provided for the transport of the S and Ku-Band equipment to ISS. Equipment activation is planned for subsequent missions. On Flight 4A, the Low Data Rate (LDR) S-band will be activated; on Flight 5A, the High Data Rate (HDR) S-Band will be switched on; and on Flight 5A.1, the Ku-Band system will be initiated. The Network is ready.

In addition, the Networks are ready for VHF support for SM and Soyuz missions. The Network resources at Wallops, Dryden, and White Sands are equipped to provide VHF-1 Air/Ground (A/G) voice to the ISS SM and VHF-2 A/G voice for the Russian Soyuz missions.

Currently, we are in the midst of high dynamics during the ISS assembly activities. Network entities have been preparing for these events for some time, and are ready to participate in ISS mission success.

By John Smith/CSOC/GSFC Code 451 and Ted Sobchak/GSFC Code 451

For more information, contact Ted Sobchak at (301)286-7813 or via email at Ted.Sobchak@gsfc.nasa.gov.

ISS Build Sequence – Looking One-Year Ahead…

Joint Spacecraft Operations Center to be Located in Antarctica

The JSOC (Joint Spacecraft Operations Center) is a tri-agency (NASA, National Science Foundation, and Air Force Space Command) initiative to consolidate equipment for existing efforts at McMurdo Station, Antarctica for both NASA and the National Science Foundation (NSF). Implementation of JSOC will also provide equipment space for future capability envisioned for the Air Force Space Command. The text below outlines the reasons behind this effort for the three agencies involved.

NASA, in conjunction with the NSF, currently owns and operates a 10-meter S-/X-band ground station named the McMurdo Ground Station (MGS), located at McMurdo Station, Antarctica. MGS was initially established for joint NSF-NASA collaboration for the real-time recovery of satellite synthetic aperture radar imagery data of Antarctica produced by the RADARSAT, ERS-1, and ERS-2 spacecraft. With a southern latitude of 77º 50´, the MGS allows station contact every satellite orbit for polar low-earth orbit (LEO) spacecraft.

The MGS equipment and areas are dispersed in several geographic areas around McMurdo, with limited floor space complicating maintenance and operations functions. Also, the harshness of the Antarctic environment adds to the maintenance and operations difficulties. Consolidating the currently dispersed NASA MGS equipment into a single, large facility will improve operability, reliability, maintainability, and availability; relieve space limitations; and generally enable future growth in response to expanding mission needs.

NSF presently houses its McMurdo Station Telephone Central Office and computer Network Operations Center (NOC) in two structures that date to the mid 1960s. These buildings, which were co-opted for NSF use, do not permit future expansion. They also do not allow for the proper environmental control (humidity, dust, and temperature), physical configuration/space, access control, and fire suppression that mission critical communications functions require.

The sizing of the Telephone Central Office and NOC is a strategic issue that must be addressed for the successful management of the Information Technology infrastructure at McMurdo Station. These systems are critical to the success of the United States Antarctic Program (USAP) science program and operational support infrastructure. Information Technology modernization projects, now in the planning stages, require improved facility space.

To upgrade the Air Force Defense Meteorological Satellite Program (DMSP) capabilities, the Air Force has identified McMurdo Station as an ideal location to receive spacecraft downlink telemetry. McMurdo Station will allow station contact every satellite orbit for Air Force polar LEO DMSP spacecraft. This contact will enable the USAF to improve its time of delivery latency for DMSP data customers. The addition of DMSP tracking capability at McMurdo Station, when coupled with anticipated future spacecraft on-board enhancements, will enable nearly full orbit recovery of fine resolution imagery—a contrast to the ~40% coverage now possible.

Improvements to the current McMurdo satellite tracking infrastructure that was established by NASA and NSF are required to enable United States Air Force satellite tracking activities, due to the inadequacy of the current control room and mission operations facility space. Establishing an appropriate facility infrastructure is a necessary precursor to support of future DMSP satellite data recovery activities.

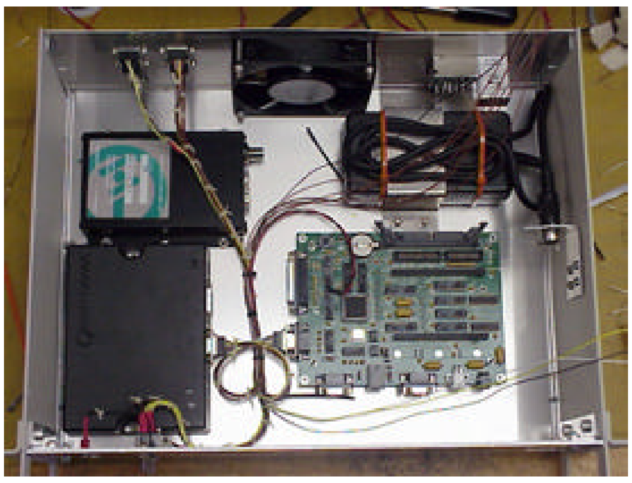
According to the latest schedule, many of the JSOC construction materials and parts have already been purchased, with the remainder to be acquired shortly. Those items will be loaded on a ship to arrive in McMurdo in February, 2001. JSOC construction will commence shortly thereafter. The building is scheduled to be ready for occupancy in January, 2002.

By Garry Fisher/GSFC Code 452, Kevin McCarthy/GSFC Code 450, and David Miller/ITT

For more information on JSOC, please contact Garry Fisher via email at Garry.W.Fisher.1@gsfc.nasa.gov, or via telephone at (757) 824-1661.

New Flight Modem Technology to Enable Cost Savings

The Flight Modem project is an Advanced Range Technology Initiative (ARTI) managed from Goddard's Wallops Flight Facility in Wallops Island, VA. (For more information about ARTI, see the article in the July 2000 issue of *The Integrator*.) The Flight Modem is designed to enable a launch vehicle to transmit data directly to a remotely operated control center via a commercial space-based data network satellite system (Qualcomm's Globalstar system).



This assembly of the aircraft flight modem package consists of a GPS receiver, Qualcomm GSP1600 tri-mode phone junction box, an Embedded RLC Windows CE computer and a 120VAC to 5VDC power regulator. The Qualcomm tri-mode GSP1600 phone will be mounted in a car-kit cradle to the front panel of the box.

This new technology is expected to provide an autonomous link for flight safety, thereby eliminating the logistics challenges, operations resources, and cost of a single radar system for tracking. This cost savings can be passed on to the science communities, to produce cost effective missions that partner with commercial COTS products.

The Flight Modem project is progressing well. So far, Wallops Flight Facility (WFF) engineers have achieved successful bit error rate testing from a fixed ground source, through the Globalstar satellite system, to an IP address over the Internet. In November 2000, a data-enabled Globalstar cell phone (GSP1600) will be flown on board an E-9A aircraft at 25,000 ft. over a 200 square mile flight path in the Gulf of Mexico. In addition, we may have an opportunity to fly the flight modem on board a sounding rocket from Kiruna, Sweden in March 2000. WFF engineers are awaiting word from Qualcomm as to when the gateways in Europe and Finland will be enabled for packetized data.

In later tests, a long duration balloon (LDB) will be used to carry the first original equipment manufacturer (OEM) IP satellite packet modem module (GSP1620) up to 125,000 ft. for 24 to 48 hours from Fort Sumner, New Mexico. The final platform will utilize a sounding rocket to demonstrate the same concept. On each platform, pseudo random noise (PRN) data will be used as a quality measurement tool to determine bit errors and frame drop outs. Latency measurements through the Globalstar network will be made with GPS receivers.

By Dwayne R Morgan/GSFC/WFF Code 584.W

For more information about the Flight Modem, please contact the author via email at Dwayne.R.Morgan.1@ gsfc.nasa.gov, or via telephone at (757) 824-1349

Space Operations Architecture Evolution Roadmap Effort Underway

NASA's Space Operations Management Office (SOMO), located at the Johnson Space Center, is responsible for overseeing technology development and architecture upgrades to enable future NASA missions and reduce cost. As part of this effort, SOMO is constructing an overall architecture evolution roadmap driven by future mission requirements, to help guarantee that NASA's space operations architecture effectively evolves to meet customer needs.

Many of these new technologies and upgrades are being implemented here at GSFC. Code 450 is managing numerous diverse projects—from development of advanced antennas and transponders, to the design of resource- and time-saving tools that will enable autonomous spacecraft operations. It is imperative that the scope and relevance of these activities (and those at other centers, as well) be communicated to SOMO, as they proceed to construct the comprehensive roadmap for the entire NASA architecture.

To facilitate this information transfer, Code 450 is formulating a roadmap for the evolution of the space operations architecture for GSFC. This effort will include an initial analysis of NASA Enterprise goals and customer needs. From this data we will be able to derive a set of capabilities that must be achieved to enable the science and operational goals of our future missions. In the GSFC roadmap each activity will be clearly linked to the mission need it supports.

As the roadmap effort proceeds, look for additional details in future issues of *The Integrator.*

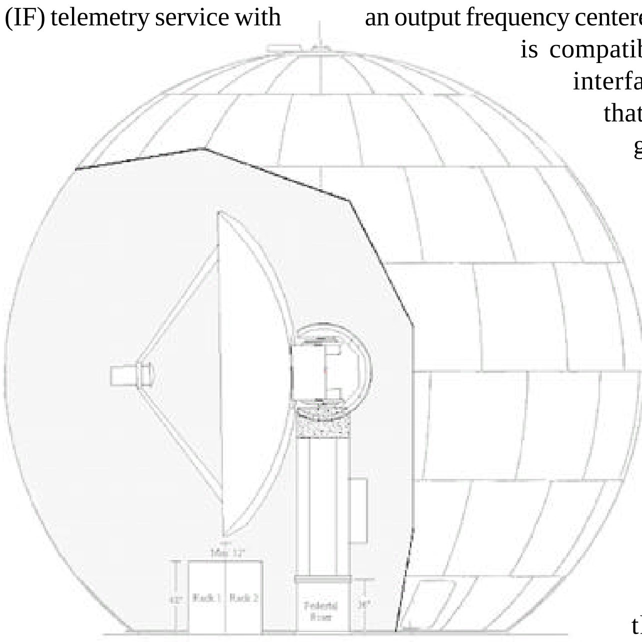
For further information regarding the SOMO or GSFC roadmap endeavors, please contact Roger Clason at (301) 286-7431.

Ka-Band Transition Product Will Upgrade Networks

The Ka-Band Transition Product (KaTP) is an ongoing GSFC Code 450 effort, the purpose of which is to support development of interoperable Ka-Band data services for NASA's Space Network (SN) and Ground Network (GN). During KaTP development, these data services will evolve through infrastructures upgrades within the SN and GN. Additionally, the KaTP will leverage NASA and COTS technology to conduct demonstrations of the SN and GN high data rate Ka-band capabilities (600 Mbps and higher), providing the impetus to guide the future direction for Ka-band data service provisioning.

While the SN has been provided a Ka-Band capability via TDRS H,I,J modifications, this capability is currently only available on the 225 MHz return channels (consistent with the TDRS H,I,J frequency plan). KaTP SN infrastructure upgrades consist of modifying the SN ground stations at The White Sands Complex (WSC) to take advantage of the new TDRS H,I,J spacecrafts' 650 MHz Ka-band space-to-space return link in the 25.25 GHz to 27.5 GHz range. Implementation of these upgrades will also provide interoperability in the Ka frequency domain with ESA and NASDA, consistent with the Space Network Interoperability Program (SNIP) Frequency Recommendations. The infrastructure upgrade will initially provide an IF return service with an output frequency centered at 1200 MHz.

KaTP GN infrastructure upgrades consist of a demonstration ground terminal that will be installed at NASA's Wallops Flight Facility to support Ka-band and S-band communications with low earth orbiting spacecraft. The GN terminal is being designed to support NASA S-Band command (2025 to 2120 MHz), S-Band telemetry (2200 to 2300 MHz), and Ka-Band telemetry (25.5 to 27.0 GHz). The S-band command and telemetry initial capabilities will be similar to the current GN S-band services. The Ka-band capability will provide an intermediate frequency (IF) telemetry service with an output frequency centered at 1200 MHz, that is compatible with the SN IF interface. We anticipate that the demonstration ground terminal will serve as a vehicle to evolve and demonstrate technology advances (bandwidth efficient modulation, advanced coding, etc.) in both S and Ka band areas



Cut-Away View of Radome Housing the WFF S/Ka-Band 5 Meter KaTP Antenna

Concurrent with these development activities, project personnel are performing technology studies and developing a demonstration plan to implement equipment for data demodulation, decoding, processing, and storage that will be compatible with the SN and GN IF interface for Ka-band service. We intend to perform end-to-end Ka-band data service demonstrations up to data rates of at least 600 Mbps (with a goal of 800 Mbps or higher) for both the SN and GN—all using technology made available by NASA and industry with limited custom development. To the extent possible and practical, these Ka-band demonstrations will include bandwidth-efficient modulation and coding techniques such as Offset Quadrature Phase Shift Keying (OQPSK) with baseband filtering, Feher Quadrature Phase Shift Keying (FQPSK), Gaussian filtered Minimum Shift Keying (GMSK), 8-phase Shift Keying/Trellis Coded Modulation (8-PSK/TCM), Turbo codes, and punctured codes as well as demonstration of the capability to support SNIP, IP, and Consultative Committee for Space Data Systems (CCSDS) standards.

The KaTP system requirements review occurred in July 2000, and the SN and GN system design reviews are planned for December 2000. The SN and GN infrastructure implementations are scheduled for completion by the end of FY01, and the demonstrations are slated for completion by the end of FY02.

By Mark Burns/ITT Industries

For further information contact Roger Clason at (301) 286-7431. The NASA/GSFC Ka-Band web site at http://classwww.gsfc.nasa.gov/kaband/ is currently being updated to include Ka-Band Transition Product information and documentation, and will be available in the near future.

TDRSS Online Information Center Is Updated

The TDRSS Online Information Center has changed. We recently updated our homepage to include the latest navigation features and up-to-date information about TDRS H, I, J.

We also continue to maintain and enhance the many features of our site, including links to the Demand Access Systems Engineering web site, a monthly calendar of upcoming events, and link budget calculators to assist you in determining if your mission can be supported by TDRSS.

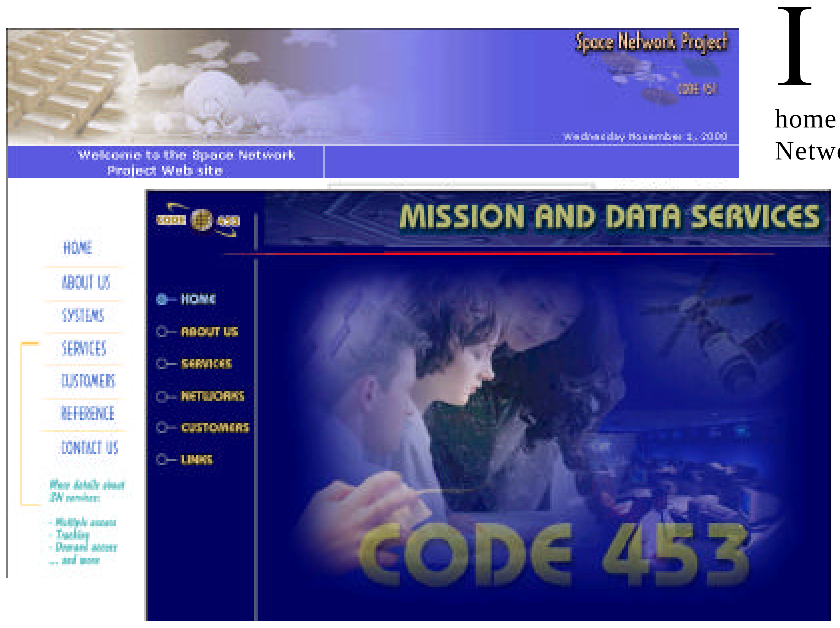
Our Javascript search engine will help you locate the specific information you require. Or, use our feedback form to email your questions to us. We will direct your query to the appropriate expert, and return an answer promptly to you via email. The site is updated twice monthly to ensure information is current and accurate.

The web site can be found at *http://msp.gsfc.nasa.gov/tdrss/*

Detailed information is currently available on:

- The Tracking and Data Relay Satellites (including TDRS H, I, J)
- Demand Access
- The White Sands Complex including WDISC
- Guam Remote Ground Terminal
- McMurdo TDRSS Relay Terminal System
- TDRSS Telecommunication Services
- Customer Communication Systems and Products (including Transponders)
- TDRSS Applications
- PORTCOM, ECOMM, and TILT
- Plus much more…

Code 450 Web Sites Have a New Look!



A "peek" at the new web sites for Code 451 and Code 453

In addition to updating the content, we recently revamped the "look and feel" of two of our web sites—the home pages for Code 451 (the Space Network Project) and Code 453 (the Mission and Data Services Project). Take and look, and tell us what you think! When the Code 450 reorganization is fully in effect, the web pages will again be updated to reflect the changes that occur.

The web sites can be found at: *http://msp.gsfc.nasa.gov/451* and *http://msp.gsfc.nasa.gov/453*

Comments regarding the web sites can be directed to Lynn Myers via email (lynn.myers@gsfc.nasa.gov) or phone (301-286-6343).

Coming Attractions

Demand Access System Passes Review

The Space Network Demand Access System (DAS) has completed a requirements review and is progressing through preliminary design. DAS is a new system that will allow customers to receive telemetry continuously, regardless of geographic position. DAS utilizes existing TDRS Multiple Access (MA) antenna arrays to form beams on customers using new, compact, low-cost, state-of-the-art equipment. The DAS will allow customers to obtain support without the use of complicated and burdensome scheduling processes. The DAS will use the new SN Web Services Interface (SWSI) as the interface to enable customers to control and monitor their services. DAS telemetry will be provided using IP packets in a variety of formats. DAS operations are scheduled to commence in April 2002.

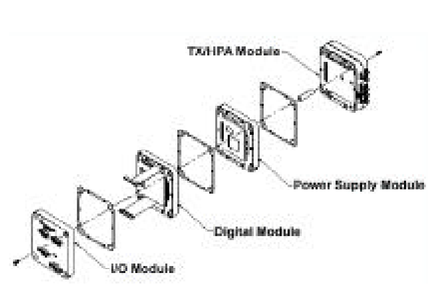
By Tom Gitlin/GSFC Code 451

For additional information about the DAS, please contact the author via email at tom.gitlin@gsfc.nasa.gov.

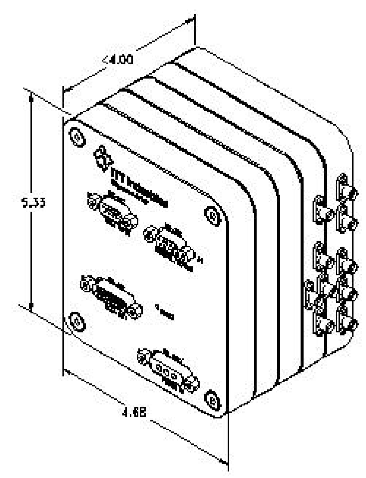
Small Expendable Launch Vehicles Transmitter in the Works

Space Network support of Expendable Launch Vehicle (ELV) Programs continues to grow, as additional initiatives under development promise a long and productive relationship between the Space Network (SN) and ELVs. NASA continues to work with ITT on development of the Low Power Transceiver concept and its potential for use with SN range safety efforts (see article on Range Safety efforts on page 24). NASA and ITT are also working on a “Small ELV Transmitter”.

The Small ELV Transmitter represents a new; enabling technology that provides a “cost effective” means for the Small ELV community to use SN for status/telemetry. We will leverage proven Low Power Transceiver (LPT) technology with a new, highly efficient upconverter and 30-watt power amplifier. The Small ELV Transmitter will utilize an FPGA (Field Programmable Gate Array) based digital modulator for flexibility and precision. This highly configurable transmitter will support DG2 Mode 2 and STDN transmit functions in the frequency range of 2200 MHz to 2300 MHz at data rates up to 4 Msps per channel.



Breakout drawing of the Small ELV Transmitter showing individual circuit cards and frames



Fully assembled Small ELV Transmitter

We are emphasizing a low risk, lightweight, small design with high system efficiency. Much of the design risk will be mitigated, since the Small ELV Transmitter will use three LPT modules, including the Digital Signal Processing module. The Small ELV Transmitter will weigh less than 7 pounds, have a volume of less than 100 in^3, and have a system efficiency of at least 30%.

The Small ELV Transmitter will be designed for low cost, quantity production and testing. The transmitter’s modular circuit card architecture and flexible FPGA based digital modulation make it ideal for rapid tailoring to a diverse set of customer needs. One engineering model and one qualification model will be built. The qualification model will be tested for functional, performance and environmental capabilities. It will then be possible to quickly and affordably tailor the qualification model to most any ELV application.

By David Schuchman/ITT

For additional information on the Small Expendable Launch Vehicle Transmitter Project, contact the author at (703) 438-8178.

The Aqua Mission: Investigating Our Planet

One of the endeavors specifically stated in NASA's Earth Science Enterprise strategic plan is "to understand the total Earth system and the effects of natural and human-induced changes on the global environment." The Aqua mission is one of a series of space missions designed to allow scientists to do just that. With six different on-board sensors pointing toward Earth, Aqua will provide data enabling the measurement of environmental changes, and facilitating identification of the causes of those changes.

Aqua's Atmospheric Infrared Sounder (AIRS) will measure upwelling infrared and visible radiation from the Earth, providing data on our climate and weather. The Advanced Microwave Sounding Unit (AMSU-A) is a passive scanning microwave radiometer that will supply atmospheric temperature and water vapor data in both cloudy and cloud-free areas. Precipitation rate, water vapor content, and surface moisture data will provided via Aqua's Advanced Microwave Scanning Radiometer-EOS (AMSR-E) instrument. Two Clouds and the Earth's Radiant Energy System (CERES) instruments will operate together (one scanning cross track, the other scanning azimuthally) to furnish a complete picture of the radiative energy flux emanating from Earth. The Humidity Sounder for Brazil (HSB) instrument, in conjunction with the AIRS, will supply an accurate humidity profile of our atmosphere. The sixth instrument, the Moderate Resolution Imaging Spectroradiometer (MODIS) will provide a wealth of imagery data on cloud properties, land cover and land use change, vegetation dynamics, land surface temperature, volcanic effects, sea surface temperature, snow cover, sea ice, and other parameters.

All of these scientific instruments are now successfully integrated on the spacecraft. Aqua has accomplished its hardware comprehensive performance testing, and has successfully passed required system Electromagnetic Compatibility (EMC) tests.

Aqua will primarily utilize the Alaska and Svalbard ground stations for its communications requirements, with the Space Network (SN) serving as a backup system. In late October, the Compatibility Test Van (CTV) was used to test Aqua's communications capabilities. Engineers made modifications to the CTV, so that ground station compatibility testing in the X- and S-bands could be accomplished, in addition to SN compatibility testing.

Aqua will be launched on a Delta II 7920-10L from Vandenberg's Space Launch Complex 2 (SLC-2) on approximately July 12, 2001. It will be placed in a sun-synchronous polar orbit that will cover the Earth's surface every 16 days. Aqua's useful mission lifetime is expected to be six years.

Watch for updates on Aqua's progress in future issues of *The Integrator*.

For more information on Aqua, please contact Chris Morris/GSFC Code 422 at (301) 286-4882, or visit the Aqua home page at http://eos-pm.gsfc.nasa.gov.

Automated Transfer Vehicle Elegant Breadboard Transponder/Space Network Demonstration

The NASA GSFC/JSC Visiting Vehicle Team has been working with the European Space Agency (ESA) Automated Transfer Vehicle (ATV) program for several years, executing a valuable exchange of mission support information. The ATV flight profile is designed such that the Space Network (SN) provides mission support from ATV insertion through areas close to docking, during a Parking Phase away from the ISS, and during vehicle re-entry into the Earth's atmosphere.

Communications with the ATV via TDRSS are required for mission success. Therefore, checking out the ATV/TDRSS interface early in the development process is valuable to

(continued on page 24)

(continued from page 23)

both ESA and NASA. NASA personnel spent many months working with ESA on a TDRSS Compatibility Test program. Both ESA and NASA agreed that a thorough Compatibility test program was necessary for testing communications. In addition, however, ESA proposed conducting an ATV transponder demonstration with TDRSS to get the earliest possible look at the functionality of the transponder design as it interacts with TDRSS.

ESA and the vendor team at Alcatel in Madrid, Spain proposed using the ATV Elegant Breadboard (EBB) version of the transponder as the demonstration article. Using this design version in-line will provide "a representative RF signal from/to the TDRSS system…" The demonstration "…is considered as a 'development' check to give confidence in the correct understanding of SNUG (Space Network User's Guide) … and to check the ATV transponder demodulation algorithms performance with a 'real' RF signal in order to optimize the design before freezing ASIC definition." The demonstration is a one- time event intended to determine whether the design is ready to proceed to a more final ASICS design. The demonstration was scheduled for October 24-27, 2000 with both teams looking forward to gaining valuable insight into the ATV/SN interface.

The ATV EBB transponder demonstration article will be located in Madrid Spain. Through pre-demonstration coordination and via a real-time voice loop between Madrid, GSFC, and White Sands Complex (WSC), the demonstration activities will commence with WSC providing "test" data in a forward link and the ATV EBB transponder providing a return link signal. Both the ESA and NASA teams are expecting productive results.

By John Smith/CSOC/ GSFC Code 451

For further information, please contact Ted Sobchak/GSFC at (301) 286-7813, or via email at Ted.Sobchak@gsfc.nasa.gov.

Space-Based Range Safety Update

GSFC's efforts to create a space based range safety option continue and are moving forward to the next level. The space-based range safety concept has successfully passed a couple of important milestones on the road to reality.

As mentioned in the July issue of *The Integrator*, the GSFC team presented the concept at the SpaceOps 2000 conference (available at *http://nmsp.gsfc.nasa.gov/range/*) The presentation went well; in fact, international entities expressed interest in a space-based range concept.

Also mentioned in previous articles was the STS 107 Communications and Navigation Demonstrations on Shuttle (CANDOS) experiment. This Hitchhiker experiment is currently planned for launch in June 2001.

The objectives of the CANDOS experiment are to provide a demonstration of the Low Power Transceiver (LPT) in a space flight environment, to demonstrate the capabilities of IP in space, to demonstrate the navigation capabilities of onboard state vector generation and GPS operations, and to demonstrate range safety capabilities.

Specifically, the CANDOS experiment is intended to achieve the following range safety objectives:

1. Error-free passes utilizing simultaneous TDRS and ground forward link interrogation of the LPT

2. Verification of the performance of the LPT and return link data under circumstances similar in nature to those encountered in a range safety environment

On another front, the GSFC space-based range safety team submitted a proposal to the KSC Advanced Development Office for the Second Generation Advanced Development activities. KSC management selected the proposal as one of five to be further investigated. A team from Dryden Flight Research Center (DFRC) also submitted a proposal called Satellite Telemetry Acquisition and Range Study (STARS). As a result of the similarities between the two proposals, KSC is working with GSFC and DFRC to combine the two proposals into a single program/project.

By Mike Stager /CSOC/ GSFC Code 451 and John Smith /CSOC/GSFC Code 451

For further information, please contact Ted Sobchak/GSFC at (301) 286-7813, or via email at Ted.Sobchak@gsfc.nasa.gov .

NASA's Vision of Future Space-based Communications: The Integrated Interplanetary Network

NASA and other space agencies have plans to explore all the planets and some of the moons within our solar system. Initially, NASA is planning to send a multitude of missions (landers, penetrators, rovers, and orbiting spacecraft, etc.) to explore Mars, with the goal of being able to support human presence by the year 2020. NASA, therefore, needs a telecommunications infrastructure around Mars to support the data throughput and tracking requirements of these missions. At the same time, NASA is embarking on the design of the next generation space telecommunications infrastructure to meet future near Earth mission requirements (see the article on the Future Space Network Architecture Study on page 26). Significant cost savings and improved throughput capabilities can be realized by designing the next generation telecommunications infrastructure so that it satisfies the future telecommunications requirements of both interplanetary exploration and near Earth satellite communications.

NASA intends to build the IIN in a phased approach; the addition of each Data Relay Satellite (DRS) in the IIN will add additional capability to the network. At first, the key nodes will consist of DRSs around Earth, and at least one DRS at Mars. Over time, the IIN will grow throughout the solar system as additional needs arise. Each relay will act as a node in a network that increases the network throughput capabilities and connectivity to the Earth. An example of a possible configuration is shown in Figure 1.

The IIN goal is to ensure that all nodes in the network, including the Earth and Mars DRSs, include some essential features—such as forward compatibility and flexibility—that will allow each node to communicate with every other node and with planetary missions. The architecture must be able to support the high data rates needed for human space flight missions, as well as the lower rates used when communicating with very low power transmitters, or when communications span large distances. In addition, the communications design must be versatile enough to simultaneously support widely distributed, multiple spacecraft (typically referred to as sensor webs) that transmit at the high data rates needed to

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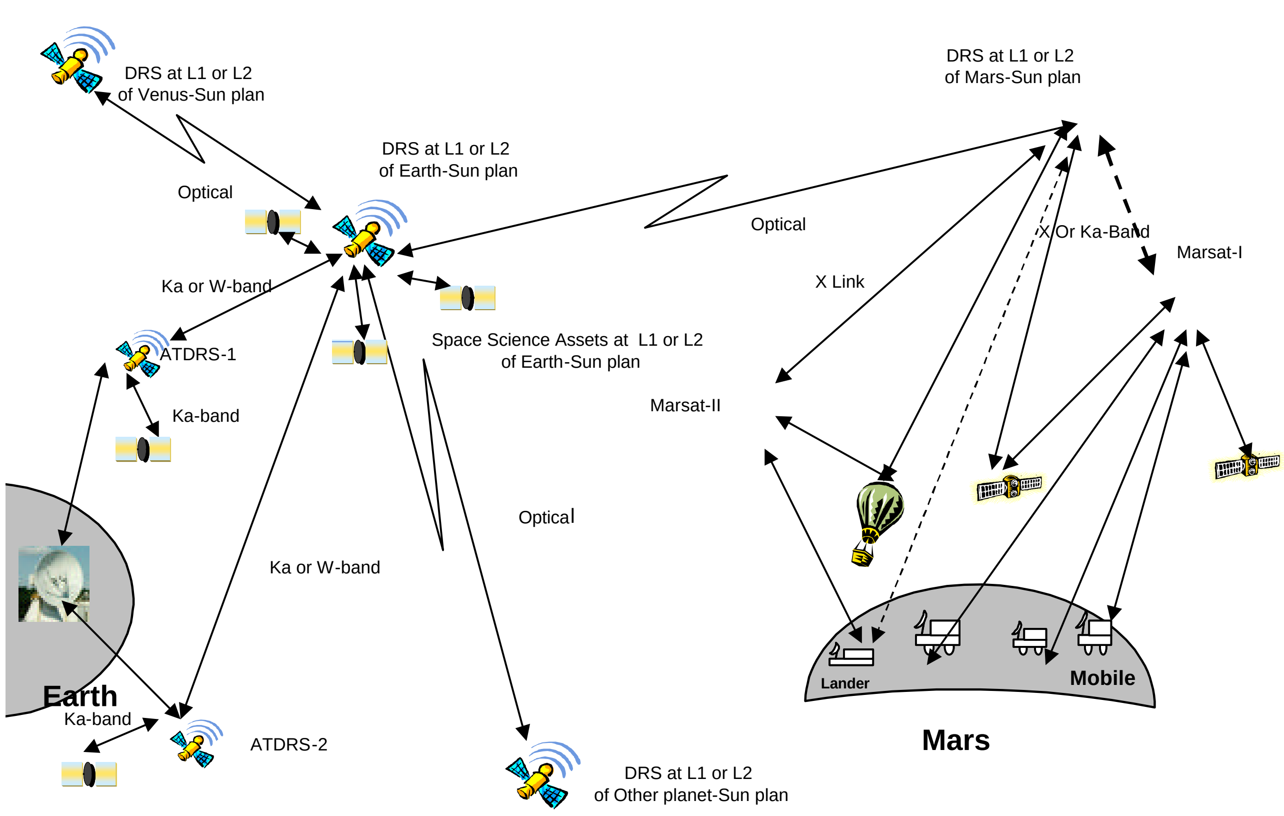

Figure 1. A vision for the Integrated Interplanetary Network (IIN)

(continued from page 25)

monitor weather, map terrain, or study other natural phenomenon.

The utilization of new enabling technologies is essential to a successful IIN design. For a look at some of these technologies, check out the white paper on the MSP web page at URL: *http://msp.gsfc.nasa.gov* in the News/Updates section.

GSFC personnel are currently exploring creative and original concepts for NASA's IIN. GSFC will be defining key parameters and characteristics of communication and navigation networks to support exploration, robotic outposts, and piloted missions to Mars and other planetary systems. Careful use of this information will ensure that the original IIN architecture need not be modified as the network expands throughout the solar system. The study will evaluate ways to maximize the potential science return from the ongoing series of NASA missions to Mars as early as possible, while remaining robust, flexible, and modular so as to facilitate the IIN evolution.

By Badri Younes/GSFC/Code 450

For additional information on the IIN, please contact the author at (301) 286-5089 or via email at badri.younes@gsfc.nasa.gov.

GSFC Undertakes Future Space Network Architecture Study

Since the 1980s, the NASA Space Network (SN) has matured into a highly reliable system capable of meeting its customer needs into the 21st century. The current NASA mission model indicates a need for a 5-TDRS constellation well beyond the 2008 timeframe. By the year 2005, the first generation TDRSS spacecraft (F3-F7) will have reached or exceeded their design life expectations. The TDRS H, I, J spacecraft, which are being launched over the time frame 2000-2003, have been designed for an on-orbit operational life of 11 years. Because the time period from architecture study to spacecraft launch can span 7 to 9 years, the GSFC Mission Services Program (MSP) has initiated an architecture study to ensure the uninterrupted continuation of SN services.

The MSP study, called the "Future Space Network Services Architecture Study," will determine the needs, possible architectures, and available technologies for a next-generation NASA SN. The main focus of the study is on the continued support of future near-earth NASA missions, but the study also considers NASA's needs for deep space and interplanetary communications. Approaches for efficiently integrating the SN and GN (Ground Network) with the Integrated Interplanetary Network, (IIN) architecture are being considered. (See the article on page 25 for more information about the IIN.) The current architecture study will be completed in March 2001.

A wide spectrum of alternatives are being considered to meet NASA's future communications needs in a cost-effective manner, ranging from commercial only systems, to a continuation of a TDRSS-like system, to a joint government/ commercial system. Candidate spacecraft configurations include a TDRS H, I, J functional equivalent with minimal modifications, and augmented spacecraft with enhanced multiple access arrays, higher RF and optical frequencies, and inter-satellite crosslinks.

The criteria that are being used to evaluate the SN architecture candidates include, but are not limited to, the ability to meet the mission model needs, cost per data bit, which is derived from life cycle cost, transition complexity, customer burden and risk.

To enhance performance and reduce costs, cutting edge technologies are being considered for integration into the future SN. New antennas for the TDRS spacecraft could include a larger phased array capable of providing support for NASA's Demand Access System but with data rates equal to SSA, steerable dish antennas for S/Ku/Ka or Ku/Ka/W band, and optical telescopes for deep space relay or inter-satellite crosslinks. For the ground infrastructure, technologies such as ground-based beamforming, fiber optics data distribution, and wideband modulators and demodulators are being studied. The range of customer technologies being considered includes software programmable transceivers and processors, GPS receivers, and onboard storage systems.

By Badri Younes/GSFC/Code 450

For additional information on this topic, please contact the author at (301) 286-5089 or via email at badri.younes@gsfc.nasa.gov.

Other Interesting Tidbits

UARS
completed
50,000 orbits
on 11/2/2000!

TRMM
begins its 1st period
of extended mission
operations on 1/1/2001.

ORRs
are scheduled for
each of the commercial
ground stations in
mid November.

ERBS
celebrates
its 6th year
on orbit!

Code 450
Mission
Services
Program

Mission Services Projects Schedule Updated

An updated **Mission Services Projects Schedule** is included in the center of this publication. This chart is currently being revised to reflect the imminent reorganization of Code 450. Look for the new schedule in the next issue of *The Integrator.*

***Edited by**:* Lena Braatz (Booz·Allen & Hamilton)
Layout & Illustration by: Sherri Tearman (Booz·Allen & Hamilton)

The Integrator can be found on line at *http://msp.gsfc.nasa.gov/integrator/*

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